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RESEARCH ARTICLE

Morphologic variability of the *Acer campestre* L. populations in Bosnia and Herzegovina

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Abstract

Morphologic variability from 25 populations of *Acer campestre* L. in Bosnia and Herzegovina was analyzed. Morphometric structure of variability and between-population variability was performed based on 10 fruit-parameter characteristics and 19 leaf-parameter characteristics using multivariate statistical analysis. Results confirmed the separation of three submediterranean populations as a group in relation to other tested populations, from which the Banja Luka population is different. Measured leaf parameters were confirmed as a predominant carrier of the morphologic separation between populations. In other *Acer* species populations within *A. monspessulanum* and *A. intermedium* species are separated mainly by fruit and much less by leaf parameters. The southernmost submediterranean populations from Trebinje, Ljubuški, and Mostar regions have smaller leaf areas, which consequently places them within the same morphologic group; their variability is in tight connection with eco-geographical factors, where the ecological distance is a much better predictor of morphological variability compared to geographical distance. The air temperature had the biggest influence on morphological variability regarding the highest in-between correlation. Achieved results may serve for the continuation of the research in other areas of *Acer campestre* to determine the interactive effect of ecological, geographical, climatic, and migrational factors on their morphologic population plasticity.

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Keywords
Differentiation, field maple, fruit, leaf, morphologic variability

Introduction

Acer campestre is a broadleaf tree species, which reaches up to 15m, in extreme conditions 25 m in height and with diameter at breast height (DBH) of 60 cm, sometimes even 70 cm (Chybicki et al. 2014). Nagy and Ducci (2004) quote heights up to 30 m, with diameter at breast height 90 cm at the age between 250 and 350 years. Šilić (1990) defines it as a bigger shrubon extreme growing sites (Kvesić et al. 2019, 2020a, 2020b).

Its ecological amplitude is rather wide (Nagy i Ducci 2004), as it may be found in areas with warmer climate; it is resistant to winter conditions, while in continental area it tollerates temperature extremes (Nagy and Ducci 2004) as well as late spring frosts at the beginning of growing period, which influence its distribution (Savill 2013; Chybicki et al.. 2014). Even as the most abundant tree species on mesophyll sites, especially in broadleaf oak forests, it reaches up to 1600 m above sea level (Praciak et al. 2013). Species isn't extremely water demanding and may not be found on location and sites with standing water with the lack of oxygen. It favours carbon substrates and also heavy clay soils; it persists in soil condition between pH 6-8. Species is extremely shade tollerant during first 10 years, while light demands progressively increase in time, especially after mast years (Nagy and Ducci 2004). It may tollerate branch removal, which makes it very suitable for the creation of green/ live fences (Jones 1945).

Chybicki et al. (2014) quote that species does not create pure stands within its natural abundance/ distribution area, but rather represents the subdominant tree species within several forest stands of Europe. In the continental part it may be found within mixed broadleaf stands especially with species from genus Quercus, Tilia, Ulmus and Castanea,while it is very rare within conifer stands (Jones 1945; FAO 2001). According to Šilić (1990), it grows in broadleaf, mixed oak stands, particularly with *Quercus robur* and *Fraxinus angustifolia*, as well as in forests of *Quercus petraea* and *Carpinus betulus*, *Quercus cerris* and *Quercus frainetto*. It grows best on deep and minerally reach soils.

Its very good adaptation ability make it one of the most characterising tree species of mixed forest stands in central and eastern Europe. In arid areas it is the subdominant tree species with oak, while in humid areas and in higher elevationsit becomes overdominated by beech and hornbeam (Nagy and Ducci 2004).

A. campestre is naturally distributed along all Europe with exception of its northern parts. Its commercial importance is small, so it is not subject to different silvicultural treatments. Therefore it may serve as a valuable model species in research of the population sensitivity to site fragmentation, as it well covers various levels of population fragmentation (Chybicki i sur. 2014; Kvesić et al. 2019, 2020a, 2020b).

Fact that Drenkovski (1979) in his observations of Balkans characterised various form of *Acer campestre* as six different species (*A. campestre* L., *A. marsicum* Guss., *A. austriacum* Tratt., *A. pseudomarsicum* (Pax) Drenk., *A. varbossianum* (Malý) Sim. and *A. pannonicum* Drenk.), indicate its wide eco-morphological population amplitude and are usually characterised under one same name (Jovanović 2000).

From all abovementioned reasons, study of this species makes it unique for the definition of various ecological, geographical, climatic factors as well as for the definition of its natural abundance, fragmentation and morphologic variability of forest populations. Provided results may also serve for the preservation of the species and its diversity as well as for its reproductive material monitoring.

With comparison of various populations within Bosnia and Herzegovina region we wanted to define influece of fruit (1) and leaf parameters (2) contribution to morphologic variability of the species and to define similarity of tested populations based on morphologic parameters (3).

Material and methods

Material for the analysis was collected from various regions and sites of Bosnia and Herzegovina, to include all ecological and geographic characteristics of the studied species (Fig. 1, Table 1).

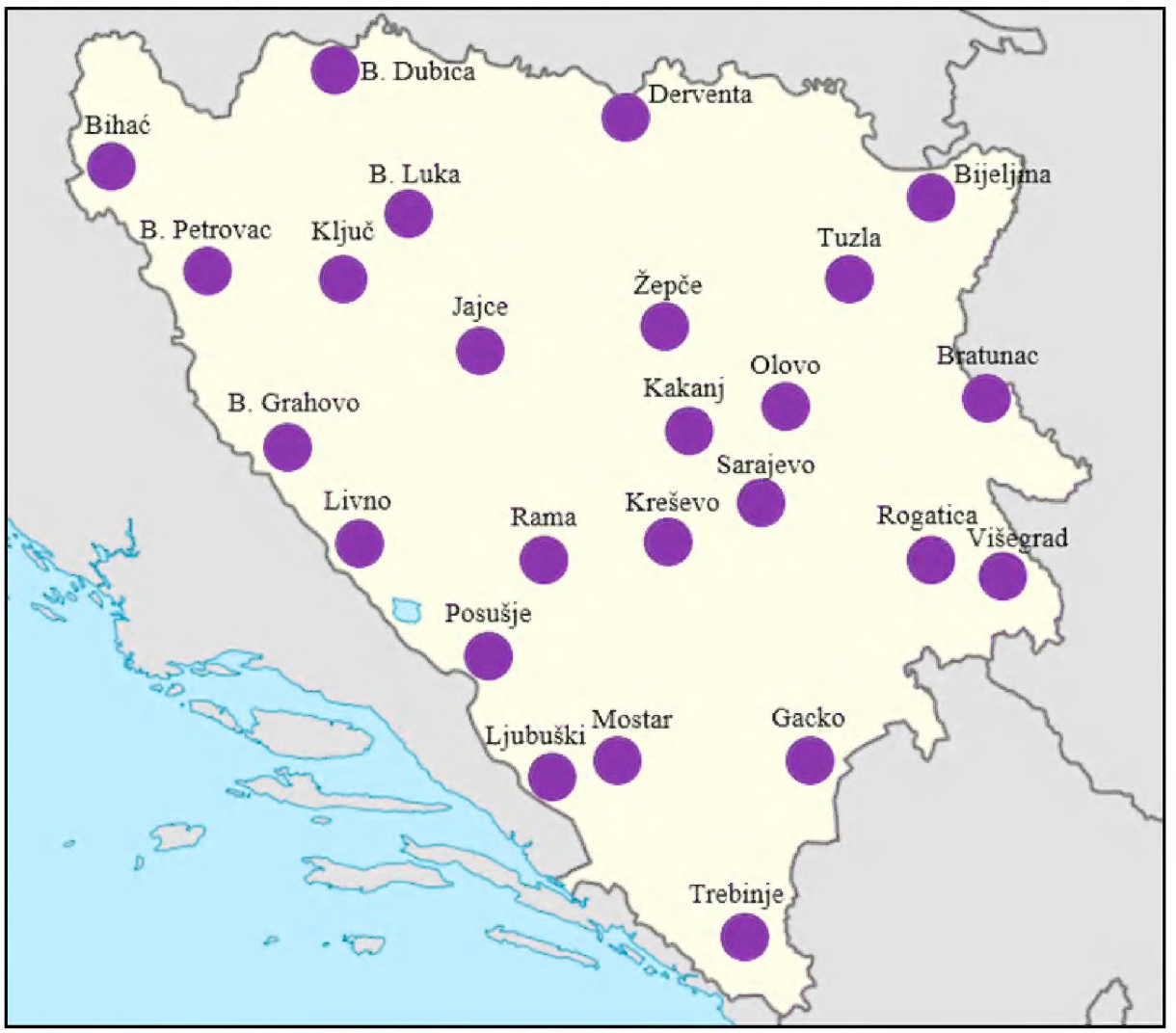

Figure 1. Position of studied populations.

Table 1. Elementar data about populations

No	Population	Locality	Population Mark	Latitude	Longitude	Altitude (m)
1	Posušje	Posuško polje	P	43° 27' 10"	17° 22' 22"	710
2	Rama	Rumboci	Ra	43° 49' 37"	17° 30' 28"	625
3	Kreševo	Polje	Kr	43° 53' 01"	18° 04' 22"	570
4	Žepče	Orahovica	Z	44° 25' 27"	18° 03' 01"	225
5	Jajce	Podmilačje	J	44° 22' 33"	17° 17' 36"	345
6	Ključ	Čađavica	Klj	44° 29' 08"	16° 53' 34"	685
7	B. Luka	Trapisti	BL	44° 48' 25"	17° 13' 36"	185
8	B. Grahovo	B. Grahovo	BG	44° 11' 12"	16° 22' 16"	845
9	Livno	Mali Kablići	L	43° 51' 19"	16° 56' 31"	750
10	B. Petrovac	Vođenica	BP	44° 37' 37"	16° 14' 57"	620
11	Bihać	Spahići	Bih	44° 51' 29"	15° 53' 17"	315
12	B. Dubica	Donji jelovac	BD	45° 04' 44"	16° 41' 25"	170
13	Ljubuški	Studenci	Lj	43° 10' 11"	17° 37' 00"	50
14	Mostar	Pijesci	M	43° 11' 40"	17° 49' 00"	225
15	Višegrad	Dobrun	V	43° 45' 17"	19° 23' 17"	375
16	Rogatica	Kukavice	Ro	43° 46' 55"	19° 00' 28"	515
17	Bijeljina	Dragaljevac srednji	Bij	44° 49' 01"	19° 01' 59"	95
18	Gacko	Vrba	G	43° 13' 28"	18° 34' 44"	1115
19	Trebinje	Dobromani	Tr	42° 47' 26"	18° 09' 25"	240
20	Derventa	Lužani	D	45° 01' 05"	17° 59' 29"	115
21	Kakanj	Donja papratnica	Ka	44° 04' 42"	18° 06' 06"	450
22	Tuzla	Donje dubrave	Tu	44° 29' 39"	18° 40' 50"	245
23	Olovo	Boganovići	O	44° 08' 18"	18° 33' 11"	510
24	Bratunac	Konjevići	Br	44° 14' 48"	19° 06' 38"	220
25	Sarajevo	Tihovići	S	43° 55' 13"	18° 22' 48"	690

Every population was represented with 12 dominant normally developped trees; 10 healthy and undamaged leaves were sampledfrom the sunny part of each crown to get representative, current fenotype condition, without modification caused by silvicultural measures (Franjić 1996; Kajba 1996; Idžojtić et al. 2006; Mikić 2007; Ballian and Čabaravdić 2005; Ballian et al. 2010, 2014; Zebec et al. 2010). Fully developed leaves were collected from the same position from all trees. In total 3000 leaves were collected and morphometrically analized from trees with exclusively generative origin. Minimal distance between two tested individuals was at least 50 m to exclude possibility of their interraction. Leaves were collected in August and September 2014 and have been herbarized immediately after collection. Morpho-

metric measurements of fruits and leaves were performed with caliper with +-0,01 mm accuracy. For morphometric analysis 10 fruit and 19 leaf parameters were defined; from all fruit parameters eight were measured and two were derived (Fig. 2).

Measured fruit parameters:

F_1 = Fruit petiole length,
F_2 = Length of fruit wing with nut,
F_3 = Fruit wing width,
F_4 = Length of fruit wing without nut,
F_5 = Length of fruit wing from its widest part,
F_6 = Fruit nut length,
F_7 = Fruit nut widthand
F_8 = Fruit angle (α).

Derived parameters:

$F_9 = F_3/F_2$,
$F_{10} = F_7/F_6$.

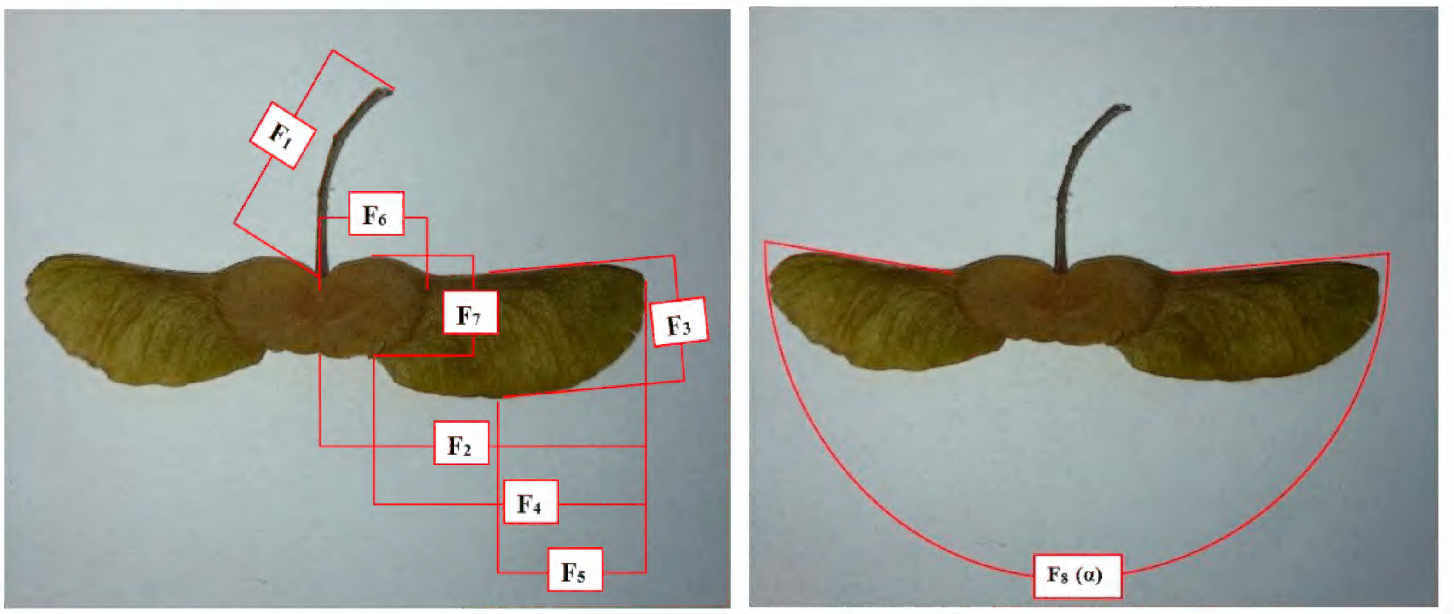

Figure 2. Morphologic fruitparameters: (F_1-F_7)- left and (F_8) - right.

From 19 leaf parameters (L) 15 were measured and 4 were derived (Fig. 3).

Measured parameters:

L_1 = Leaf petiole length,
L_2 = Maximal leaf blade length,
L_3 = Central vein length,
L_4 = Length of the leaf blade to the top of lateral lobes,
L_5 = Length of the leaf blade to the notches of lateral lobes,
L_6 = Notch depth of the leaf blade basis,
L_7 = Length of the central lobe to the notches of lateral lobes,
L_8 = Leaf blade width between tops of lower lobes,
L_9 = Leaf blade width between notches of lower lobes,
L_{10} = Maximal leaf blade width,
L_{11} = Leaf blade width between lateral lobe tops,

L_{12} = Leaf blade width between lateral lobe notches,
L_{13} = Central lobe width,
L_{14} = Angle (α) between central vein and lateral lobeand
L_{15} = Angle (β) between central vein and lower lobe.

Units for parameters L_1-L_{13} were expressed in millimeters and for parameters L_{14} and L_{15} in degrees.

Derived parameters:

$L_{16} = L_2/L_{10}$,
$L_{17} = L_2/L_7$,
$L_{18} = L_8/L_9$, and
$L_{19} = L_8/L_{11}$.

Statistical evaluation included three multivariate parts: analysis of predominant components, discriminative analysis and cluster analysis. General structure of morphologic population variability as well as the contribution of individual leaf and fruit parameters was made by the analysis of predominant components. It represents the analysis of new, artificial variables,whichrepresentthe linear combination of originalvariables (Sharma 1996), usually frequently used in biological research,

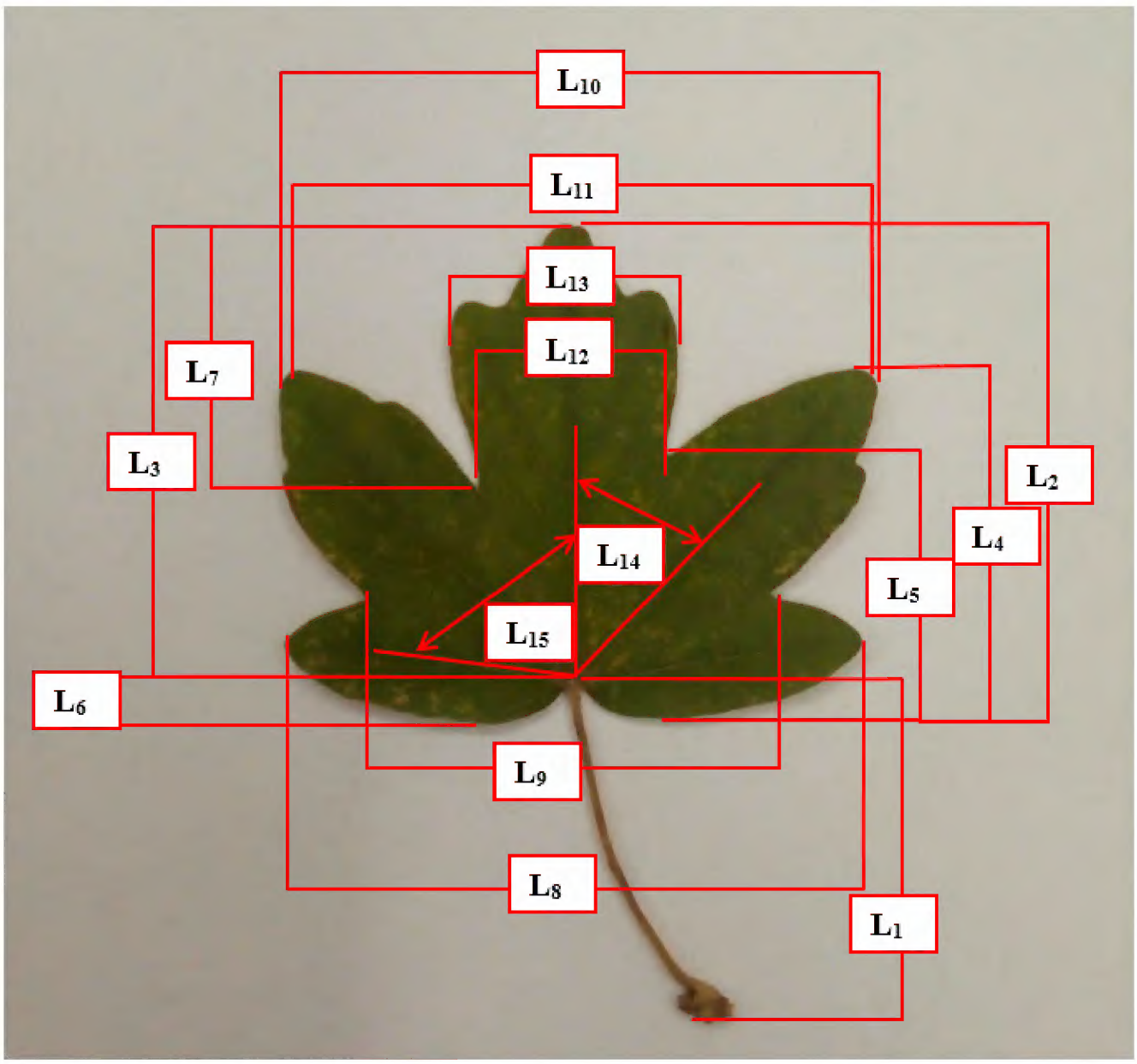

Figure 3. Analized leaf parameters.

to define number of main components, their values, variability percent and cumulative variance.In the process the Kaiser rule is usually applied (Kaiser, 1958), by which only components with value above 1 are presented.

In the analysis correlation coefficients between basic characters and main components are provided as well as community values, indicating share of individual characteristics in predominant components. Analysis was performed by the use of SPSS 20.0 program (IBM Corp. 2011), while graphical material was elaborated in the PAST 3.18 program (Hammer et al. 2001).

To verify the presence of specific morphologic groups discriminative analysis was performed, also to define the contribution of particular parameters for separating studied populations. Populations were divided into smaller groups based on numerous variables (parameters) and groupped according to their familiarity (Čabaravdić 2012). For every discriminative function its own value was calculated, variance, cumulative variance as well as cannonic correlation between the function and original parameters. SPSS 20.0 and PAST 3.18 were used.

Cluster analysis was performed in program PAST 3.18 to gather similar individual groups by the distances between studied groups (Čabaravdić 2012) in multidimensional space (Tenjović 2000), based on hierarchical aglomerative clusterisation. Complete linkage and furthest-neigbour-distance were used as well as standard euclidian distance.

Some of the measured parameters of fruit (F_3) and leaves (L_5, L_6, L_9) were not taken in the statistical calculation because they did not show statistical significance at the level of the individual and the level of the population, and between populations.

Results

Statistical analysis confirmed five significant main components with values above 1 (Table 2), which explain 88.63 % of morphologic valiability in studied species. Distribution of variance is different in each of main component, with the first explaining most of the morphological variability.

Table 2. Predominant component characteristics

Parameter	Value	Variance (%)	Cumulative variance (%)
1	14.70	58.82	58.82
2	2.65	10.60	69.42
3	2.09	8.35	77.77
4	1.49	5.97	83.74
5	1.22	4.89	88.63

For the first component (58.8% of variability) highest correlations (>0.70) were confirmed for 10 measured leaf parameters (L_1, L_2, L_3, L_4, L_7, L_8, L_{10}, L_{11}, L_{12}, and L_{13}) and two fruit parameters (F_6, F_7) (Table 3). Second main component explained additional 10.6% of variability with highest confirmed correlation for parameters L_{14}, L_{15} and L_{19} and the third main componentfor parameters F_2, F_4, F_5, F_6 and F_7. For the fourth main component highest correlations were defined for L_{17} and L_{18} and for the last, fifth main component F_1, F_8, F_9 and L_{16}.

Structure of morphological variability in studied populations is presented in Figure 4. All studied populations belonging to Herzegovinian region are located on the left side of the chart, as their average (predominantly leaf) parameters are smaller compared to average parameter values of all studied populations.

In particular four populations (Trebinje, Ljubuški, Mostar and Rama) represent group which separates from other studied populations, whiles pecial structure indicates population from B. Luka. It is showing agreement with other groups in only 2 from 12 studied parameters. Without above mentioned groups, the rest of 20 populations in the central part create homogenous unit. Differentiation between the souths populations was also obtained in the same way at the molecular level (Kvesić et al. 2020b).

Table 3. Correlation matrix of morphologic characteristics and predominating components

Morphologic parameters	Predominating component				
	1	2	3	4	5
F_1	0.07	-0.06	0.08	0.22	-0.33*
F_2	0.63	0.14	0.70*	0.07	-0.03
F_4	0.64	0.13	0.67*	0.05	0.03
F_5	0.41	0.02	0.68*	0.20	0.16
F_6	0.61*	0.21	0.55	-0.17	-0.19
F_7	0.58*	0.10	0.55	-0.14	0.34
F_8	0.01	0.01	-0.02	0.41	0.52*
F_9	0.20	-0.17	-0.19	0.14	0.40*
F_{10}	-0.04	-0.16	0.02	0.03	0.80*
L_1	0.83*	0.05	-0.14	-0.06	-0.03
L_2	0.96*	0.08	-0.21	0.05	-0.04
L_3	0.95*	-0.06	-0.16	0.07	-0.07
L_4	0.95*	-0.17	-0.20	-0.01	0.00
L_7	0.75*	0.27	-0.17	0.49	-0.13
L_8	0.91*	-0.19	-0.24	0.02	0.07
L_{10}	0.93*	0.18	-0.27	0.01	0.05
L_{11}	0.91*	0.28	-0.26	0.00	0.04
L_{12}	0.85*	0.17	-0.19	-0.38	0.02

Morphologic parameters	Predominating component				
	1	2	3	4	5
L_{13}	0.85*	0.30	-0.20	-0.18	0.00
L_{14}	-0.35	0.88*	-0.14	0.01	0.10
L_{15}	-0.22	0.84*	-0.17	0.09	0.11
L_{16}	0.30	-0.35	0.14	0.18	-0.36*
L_{17}	0.27	-0.34	-0.06	-0.78*	0.16
L_{18}	0.26	-0.35	-0.13	0.64*	0.01
L_{19}	0.44	-0.76*	-0.07	0.01	0.07

* The highest absolute correlation of morphological character in main component.

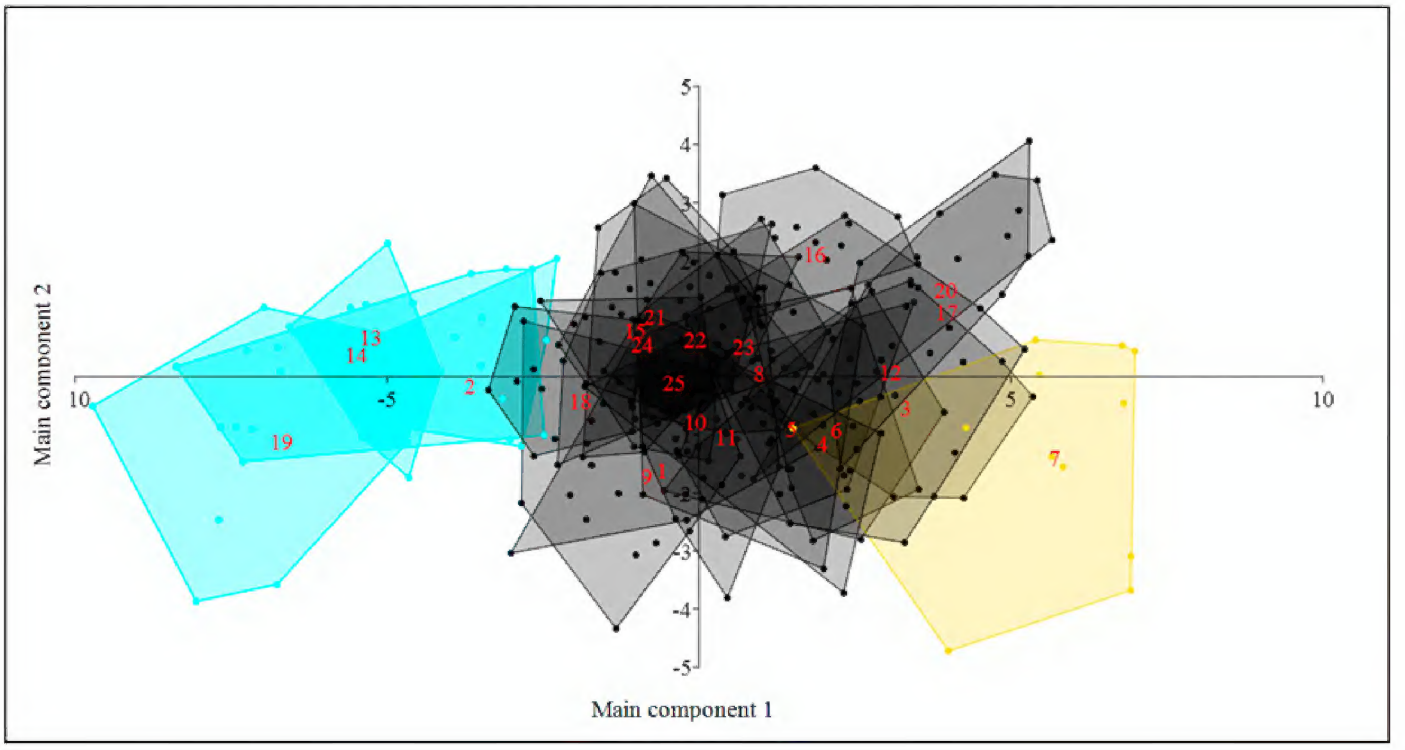

Figure 4. Population differences based on first and second main component.

In the discriminant analysis 10significant functions with significance ($p \leq 0.05$) explained 95.2% of total morphologic variability (Table 4); first function explained 62,5% (Table 5) and the remaining nine additional 32.7% of variability, respectively. In the first discriminative function populations are separated most evidently based on measured leaf parameters (Table 6) (L_2, L_{10}, L_4, L_3, L_8, L_{11}, L_1, L_{12},L_{13} and L_7). With second discriminative function onlyparameter F_4 indicated significant correlation.

Based on first three discriminative functions 2D scatterplots of studied populations with their separation are presented. On Figure 5 distinction between three submediterranean (Trebinje, Ljubuški i Mostar) population from the restis evident. Rama and Gacko populations represent link between submediterranean and homogenous remaining part of studied popularions, where only population from Banja Luka is separated. Separation is therefore based on eco-geographical characteristics of populations.

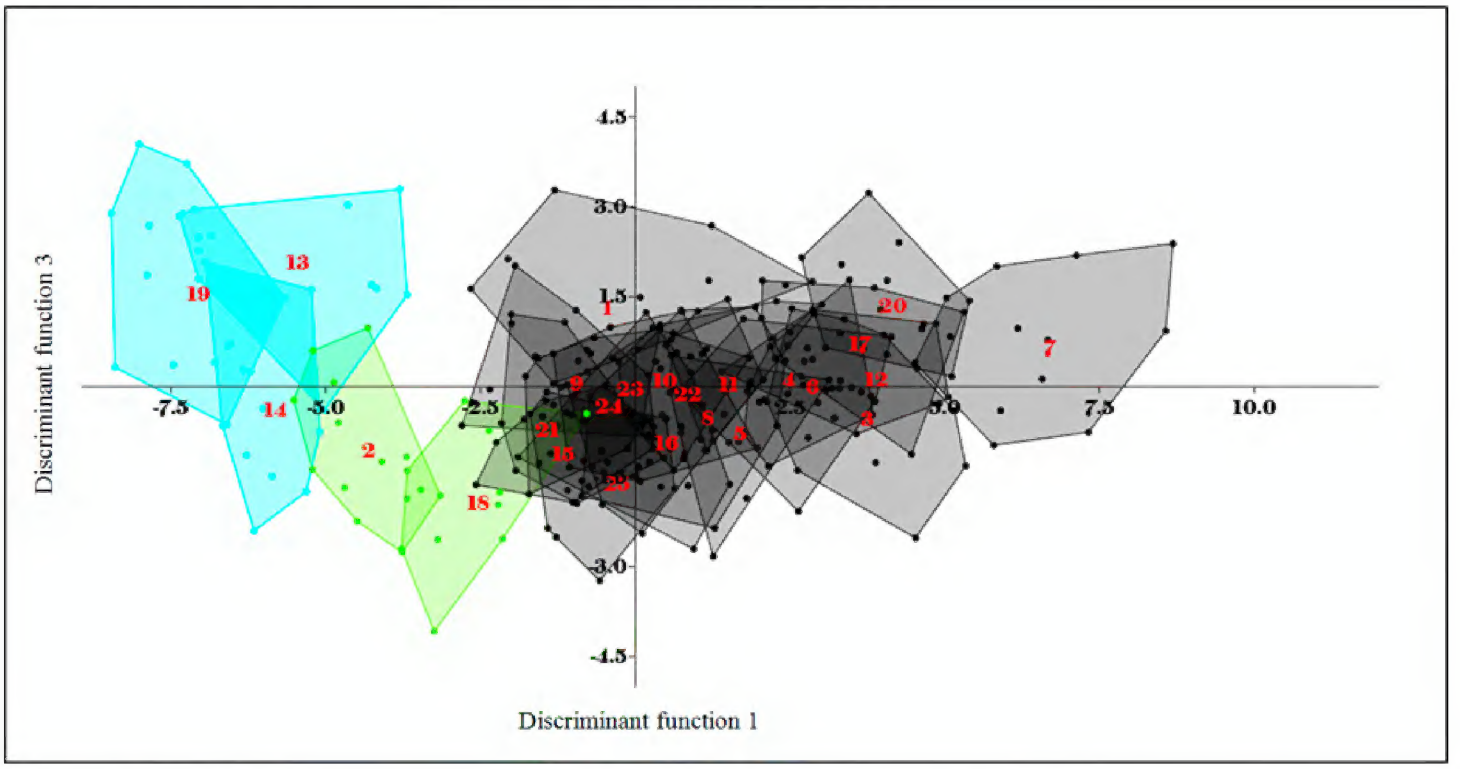

Figure 5. Population differentiation based on the first and third discriminant function.

Table 4. Statistic characteristics of discriminative functions

Discriminative function	Wilks' Lambda value	χ2	Degrees of freedom	Significance
1	0.00	2150.48	600	0.00
2	0.01	1452.24	552	0.00
3	0.01	1177.96	506	0.00
4	0.03	990.14	462	0.00
5	0.05	824.00	420	0.00
6	0.08	688.14	380	0.00
7	0.13	566.22	342	0.00
8	0.18	463.29	306	0.00
9	0.26	366.34	272	0.00
10	0.34	297.03	240	0.01

Table 5. Statistic characteristics of discriminative functions

Discriminative function	Personal value of function	Variance (%)	Cumulative variance (%)	Cannonic correlation
1	11.79	62.50	62.50	0.96
2	1.72	9.13	71.62	0.80
3	0.99	5.22	76.84	0.70
4	0.83	4.42	81.26	0.67
5	0.64	3.40	84.67	0.63
6	0.56	2.97	87.64	0.60

Discriminative function	Personal value of function	Variance (%)	Cumulative variance (%)	Cannonic correlation
7	0.46	2.42	90.06	0.56
8	0.42	2.25	92.31	0.55
9	0.29	1.53	93.83	0.47
10	0.25	1.32	95.16	0.45

Table 6. Correlation between cannonic discriminative functions and original traits parameters

Parameter	Discriminantive function									
	1	2	3	4	5	6	7	8	9	10
L_2	**0.74***	-0.04	-0.12	0.06	0.15	0.08	0.13	-0.14	0.08	-0.18
L_{10}	**0.70***	-0.03	-0.04	0.07	0.08	0.13	-0.08	-0.22	-0.01	-0.22
L_4	**0.70***	-0.11	0.04	-0.08	0.12	0.08	0.14	-0.08	-0.02	-0.11
L_3	**0.68***	-0.08	-0.19	0.01	0.01	-0.05	0.24	-0.05	-0.02	-0.05
L_8	**0.65***	-0.06	0.12	-0.05	0.03	0.05	-0.20	0.15	-0.17	-0.14
L_{11}	**0.60***	-0.01	-0.04	0.15	0.10	0.08	-0.11	-0.23	-0.02	-0.15
L_1	**0.48***	-0.15	-0.02	0.03	-0.06	-0.05	0.17	0.12	0.06	0.35
L_{12}	**0.46***	0.06	-0.16	0.29	0.20	0.02	-0.03	-0.11	0.17	0.01
L_{13}	**0.45***	0.10	-0.21	0.26	0.23	0.23	0.01	-0.09	-0.01	0.15
L_7	**0.31***	-0.01	-0.16	-0.05	0.03	0.04	0.17	-0.06	-0.08	-0.12
F_1	0.01	0.14	**-0.43***	0.34	0.09	0.23	0.03	0.21	-0.09	-0.09
F_6	0.19	0.14	0.17	**0.57***	-0.22	-0.13	0.09	-0.48	0.13	0.16
F_2	0.19	0.15	0.16	**0.55***	-0.42	-0.12	0.36	-0.02	-0.04	-0.04
F_5	0.08	0.12	0.28	**0.37***	-0.33	0.18	0.23	-0.04	-0.29	0.12
F_4	0.21	0.36	0.18	**0.44***	-0.44	-0.15	0.38	0.00	-0.04	-0.01
F_9	0.05	-0.12	0.08	-0.02	0.06	0.07	**0.41***	0.15	-0.15	0.06
F_{10}	-0.02	0.02	0.20	-0.18	-0.27	0.16	-0.03	**0.56***	0.09	-0.10
F_7	0.16	0.13	0.30	0.39	**-0.41***	-0.01	0.05	-0.03	0.15	0.05
L_{17}	0.09	-0.01	**0.17***	0.11	0.09	0.01	-0.13	-0.01	0.12	-0.01
L_{18}	0.08	0.00	0.19	-0.13	0.19	0.17	0.02	**0.22***	-0.09	-0.18
L_{16}	0.07	-0.02	-0.13	0.00	0.14	-0.11	**0.30***	0.12	0.11	0.11
L_{14}	-0.10	0.08	-0.02	0.09	0.07	0.17	-0.16	**-0.18***	0.09	-0.08
L_{19}	0.16	-0.06	0.20	-0.11	0.02	-0.05	-0.14	**0.32***	-0.14	-0.02
L_{15}	-0.06	0.10	0.06	0.07	0.18	**0.40***	-0.06	-0.21	0.14	-0.17
F_8	0.01	-0.04	-0.03	-0.01	-0.30	**0.32***	-0.31	0.26	0.16	0.06

*biggest absolute correlation between studied parameters and discriminative function

Cluster analysis confirmed results from discriminative analysis with three different subclusters: first is composed from populations Trebinje, Ljubuški, and Mostar, second by population B. Luka, and the third one by the remaining populations. The similarity between subclusters is achieved in the last step (Fig. 6).

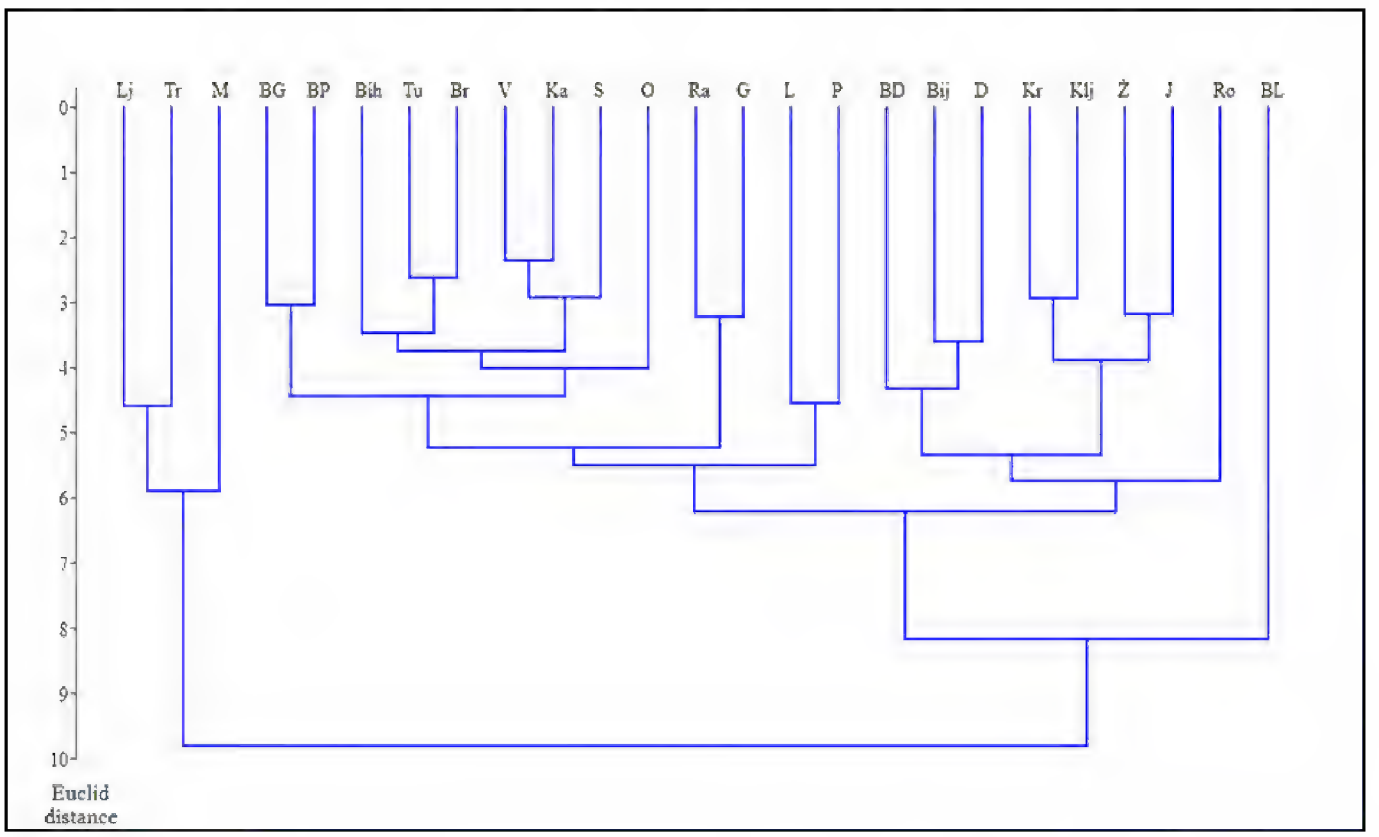

Figure 6. Euclid distance between studied populations. P – Posušje; R – Rama; Kr – Kreševo; Ž – Žepče; J – Jajce; Klj – Ključ; BL – B. Luka; BG – B. Grahovo; L – Livno; BP – B. Petrovac; Bih – Bihać; BD – B. Dubica; Lj – Ljubuški; M – Mostar; V – Višegrad; Ro – Rogatica; Bij – Bijeljina; G – Gacko; Tr – Trebinje; D – Derventa; Ka – Kakanj; Tu – Tuzla; O – Olovo; Br – Bratunac; S – Sarajevo.

According to our results, studied morphologic characteristics in relation to the geographical location/position of studied populations was confirmed by the Mantel test. Matrix between morphological distance and geographical distance was significant (0.3185; pMANTEL= 0.0003), as well as between precipitation (0.4367; pMANTEL= 0.0004) and between temperature (0.5342; pMANTEL= 0.0006), respectively.

We may conclude, that morphologic differences confirmed between different populations of *A. campestre* in Bosnia and Herzegovina origin from different ecological site conditions and geographical locations.

Discussion and conclusion

Little morphologic research of *A. campestre* in the European region may be related to its modest commercial value. In spite of its significant ecological characteristics within various ecosystems of species natural distribution, the focus of presented study targeted the within-species taxonomy of *Acer campestre* sensu latiore.

The main component analysis confirmed the morphological similarity of populations from Herzegovina compared to other studied populations despite evidenced continuity in the morphologic connection between populations. The similarity is the consequence of smaller average leaf parameters compared to the average leaf parameter values of all studied populations.

The morphologic similarity in PCA indicates a connection between morphologic variability and geographic latitude. In the case of *A. monspessulanum*, *A. obtusatum* (Tripić 2011), and *A. heldreichii* (Perović 2007) no such pattern was confirmed within species. Only in the case of *A. intermedium* population pattern is in indirect connection with ecogeographic species factors (Tripić 2011). In other *Acer* species, leaf parameters explained more morphologic variability than fruit parameters (Tripić 2011), as confirmed in our study.

Separation of populations based on discriminatory analysis as well as cluster analysis separated three southernmost Herzegovinian populations as a homogenous group (Trebinje, Ljubuški, and Mostar) and also populations Banja Luka. Both Rama and Gacko populations, belonging also to the Herzegovinian region are positioned between the submediterranean and the remaining studied populations. This is also confirmed at the molecular level by the use of microsatellite primers (Kvesić et al. 2020b).

Measured leaf parameters used for multivariate analysis represent main morphologic population separators, which was not the case in other *Acer* species (Tripić 2011); *A. monspessulanum* and *A. intermedium* within-species populations are separated more by the fruit than leaf parameters, respectively. In *A. obtusatum*, buds are the dominant discriminatory carrier, fruit and leaf parameters are insignificant, while in this research we obtained eco-level distribution. The reason for the inconsistent variability pattern in various Acer species may be different morphologic species characteristics as well as different research approaches and methodologies.

As several studies confirmed tight relation between leaf parameter variability and microclimatic conditions, the position of leaves on the shoots and the type of shoots (Melville 1939; Glišić 1975; Blue and Jensen 1988; Trinajstić and Franjić 1996; Franjić 1996; Trinajstić et al. 2001; Ballian et al. 2010. 2014; Bruschi et al. 2003; Poljak 2014; Poljak et al. 2014), special emphasis and care was dedicated to collecting the research material. Similarity analysis confirmed tighter relation with ecological parameters than geographical, with air temperature as a more significant influence than precipitation.

It is assumed that determining factors for various *Acer* species involve also *A. campestre*, according to the results of Kabaš et al. (2014) for the Serbia and Kosovo region.

Presented results may serve for the comparison and future research of other natural distribution areas of *A. campestre* and definition of interaction between ecologic, geographic, climatic, and migration factors on morphologic variability of the species.

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Appendix 1

Table A1. Descriptive indicators of fruit traits for all populations together (Kvesić et al. 2019)

Fruit trait	Number of data	Mean value	Minimum	Maximum	Standard deviation	Standard error	Variability coefficient, %
F_1	1500	12.63 mm	4.20 mm	30.30 mm	4.08 mm	0.07 mm	32.31
F_2	3000	28.35 mm	14.50 mm	43.50 mm	4.09 mm	0.07 mm	14.42
F_4	3000	27.10 mm	11.10 mm	43.50 mm	4.57 mm	0.08 mm	16.86
F_5	3000	11.11 mm	4.50 mm	21.50 mm	2.32 mm	0.04 mm	20.90
F_6	3000	8.56 mm	5.60 mm	11.90 mm	0.99 mm	0.02 mm	11.54
F_7	3000	8.14 mm	5.20 mm	11.80 mm	0.95 mm	0.02 mm	11.65
F_8	1500	182.87°	120.00°	247.00°	21.26°	0.39°	11.63
F_9	3000	0.33	0.20	0.50	0.04	0.001	12.92
F_{10}	3000	0.95	0.70	1.23	0.08	0.001	8.13

Table A2. Descriptive indicators of leaf traits for all populations together (Kvesić et al. 2020a)

Leaf trait	Number of data	Mean value	Minimum	Maximum	Standard error	Standard deviation	Variability coefficient, %
L_1	3000	35.63 mm	13.00 mm	72.00 mm	8.08 mm	0.15 mm	22.67
L_2	3000	42.94 mm	21.00 mm	69.00 mm	7.39 mm	0.14 mm	17.22
L_3	3000	38.74 mm	19.00 mm	67.00 mm	6.92 mm	0.13 mm	17.87
L_4	3000	28.60 mm	10.00 mm	48.00 mm	5.68 mm	0.10 mm	19.86
L_7	3000	19.45 mm	8.00 mm	37.00 mm	4.20 mm	0.08 mm	21.69
L_8	3000	45.15 mm	20.00 mm	84.00 mm	9.26 mm	0.17 mm	20.50
L_{10}	3000	50.77 mm	26.50 mm	84.00 mm	8.28 mm	0.15 mm	16.32
L_{11}	3000	49.91 mm	26.50 mm	80.00 mm	8.03 mm	0.15 mm	16.09
L_{12}	3000	17.46 mm	7.50 mm	35.00 mm	3.60 mm	0.07 mm	20.61
L_{13}	3000	18.41 mm	8.00 mm	35.00 mm	3.48 mm	0.06 mm	18.92
L_{14}	3000	47.23°	30.00°	75.00°	6.17°	0.11°	13.06
L_{15}	3000	85.88°	58.00°	118.00°	9.13°	0.17°	10.63
L_{16}	3000	0.85	0.63	1.09	0.06	0.00	7.23
L_{17}	3000	2.25	1.51	4.00	0.32	0.01	14.27
L_{18}	3000	1.24	0.87	1.74	0.11	0.00	9.26
L_{19}	3000	0.90	0.53	1.37	0.12	0.00	13.20